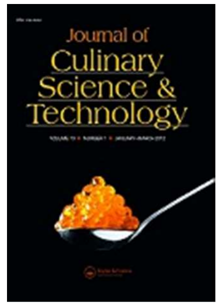

EVALUATION OF TEXTURAL AND SENSORY PROPERTIES ON TYPICAL SPANISH SMALL CAKES DESIGNED USING ALTERNATIVE FLOURS.

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ABSTRACT

The objective of this study was to evaluate the effect of wheat flour substitution by toasted corn, quinoa and sorghum flours on the overall perception and texture of typical Spanish small cakes named madeleine. In order to evaluate these characteristics, a Texture Profile Analysis (TPA) and a sensory analysis were carried out. TPA showed that the replacement of wheat flour by sorghum flour do not affected significantly texture parameters of cakes. Hedonic sensory tests were also conducted revealing that the cake prepared with sorghum flour was highly appreciated by the consumers as it got scores similar to traditional cakes made with wheat flour.

Key words: Reformulated madeleine; consumer perception; texture; alternative flour.

1. INTRODUCTION

From a commercial perspective, the development of gluten-free cakes with texture and flavor properties similar to the conventional wheat flour may be an interesting objective. Bakery products, particularly cakes, represent as one of the most consumed foods around the world. Sponge cakes, cupcakes, muffins or traditional small cake (madeleine) are connected in the consumer's mind as a delicious product with particular organoleptic characteristics (Matsakidou et al., 2010). The worldwide market of cakes currently grows with about 1.5% a year. Challenges in this market include cost reduction, increased shelf life and quality control (Wilderjans et al., 2013).

A cake batter is a complex colloidal system which is processed by being heat set. The baking of cakes leads to a light, aerated structure as well as to the formation of volatile compounds result of the Maillard reaction (Matsakidou et al., 2010).

Typical Spanish small cake (madeleine) formulation is composed of wheat flour, sugar, eggs, milk and oil. All these ingredients have different contributions to the sensory quality appreciated by consumers. Knowing interactions between ingredients is possible to predict changes on their characteristics or to reformulate new products (Baixauli Muñoz, 2007).

The liquid phase is an essential component of bakery products. Water is added by means of milk (Chiech, 2006). The milk hydrates the starch of the flour, the swollen granules began to expand and gelatinize when heated. Additionally, milk dissolves other ingredients such as sugar, during whipping and baking (Baixauli Muñoz, 2007).

In the baking industry, lipids provide characteristics such as tenderness, moist, mouth feel, lubricity, flavor, structure and shelf life (Baldwin et al., 1971; Stauffer, 1998; Wainwright, 1999; Ghotra et al., 2002; Rogers, 2004). The lipids promote the air incorporation during mixing, to give a softer structure and avoid a dry mouth feel. The trapped air bubbles accumulate water vapor and the gas provided by the dough improver expands (Stauffer, 1998; Lai and Lin, 2006; Oreopoulou, 2006).

Dough improvers are often added to flour to enhance dough elasticity and baking quality, the most widely used id sodium bicarbonate. It reacts with acids to produce carbon dioxide bubbles (Baixauli Muñoz, 2007).

Egg provides interesting functional properties, improving color and appearance to the final product (Conforti, 2006).

Sucrose has an important role to play in the development and maintenance of texture (Lindley, 1987). The concentration of sucrose solution in a recipe has a significant effect on the gelatinization temperature of the starch. This has been attributed to sucrose limiting water availability to starch granules and lowering of water activity (Beleia et al., 1996; Spies and Hoseney, 1982).

Flour provides structure, texture and flavor to baked products. Starch is one of the components in flour that strengthens the baked item through gelatinization (changes that starch undergoes when subjected to moist heat), and is one of the factors that contributes to crumb. Crumb is partially created during baking by the number and size of air cells produced the degree of starch gelatinization and the amount of protein coagulation (Jacobson, 1997).

Worldwide the most commonly flour used in the bakery industry is the wheat flour as its desirable baking characteristics have been attributed to gluten. In cake recipes, gluten is diluted with eggs, fat and sugar and is therefore less concentrated than in bread dough. Due to the lower viscosity of cake batter than of bread dough, less friction and thus, less energy is exerted on the gluten during mixing (Cauvain & Young, 2006). Most authors agree that in cake batter, gluten serves as a viscosity enhancing water binder (Donelson & Wilson, 1960; Wilderjans et al., 2008). Donelson and Wilson (1960) ascribed a greater importance to gluten proteins than to starch in the formation of cake structure. Although the development of a gluten network is limited in cake batter, gluten proteins may become important for cake structure during baking (Kiosseoglou & Paraskevopoulou, 2006; Wilderjans et al., 2008).

Substitution of wheat flour requires finding other flours from beans, rice and the "ancient grains" like amaranth, millet, quinoa, sorghum and teff which do not have gluten. Some of these flours such as teff, quinoa and bean do not generate the same texture, and these alternative flours can generate different flavor profiles (Wilson, 2012).

Currently, many of the gluten-free cakes that are available in the marketplace are of low quality, exhibiting poor mouth-feel and flavor (Peressini et al., 2012). The gluten- and allergen-free bakery industry typically must select from a broad range of ingredients to achieve the same level of functionality as in conventional formulas. During gluten-free baking, these ingredients need to replace the attributes that gluten lends to breads or baked products. When formulating products with gluten-free flour, moisture content is critical. If baking an item that is expected to rise and the dough is dry, it will be too dense. If the dough is too moist, the rise will be good but it will collapse during breaking (Martínez-Monzó et al., 2013).

In the current work the textural and sensory properties in reformulated typical small Spanish cakes (madeleine) were studied with the aim to correlated consumer preferences with objective physic-chemical properties.

2. MATERIALS AND METHODS

2.1. Flour for madeleine

Sorghum, quinoa and toasted corn flours (Moli Muntada S.L., Barcelona, Spain) were used like alternative flours. Wheat flour (Harinera Castellana, Medina del Campo, Spain) was used as control.

2.2. Batter Preparation and Baking

Batter was prepared from flour, sucrose (Azucarera Española, Valladolid, Spain), fresh whole milk (Grupo Leche Pascual S.A., Burgos, Spain), sodium chloride, refined vegetable oil (Koipesol, Madrid, Spain), whole eggs (La receta, Madrid, Spain) and baking powder (Martínez, Cheste, Spain). The ingredients were mixed in a Kenwood Major Classic mixer (New Lane, Havant, UK), as described by Sanz et al. (2009). The eggs white was initially whipped in the mixer for 2 min until stiff peaks form. In another bowl the egg yolk and sucrose was beaten until creamy smooth. The milk and oil were added and the batter was beaten for 2 minutes. Gradually the flour and baking powder were added to the batter. Finally the stiff egg white was added and the mixture. Baking was carried out at 150ºC for 12 min in a mini combi oven steamer OES 6.06 (Convotherm, Manitowok, Eglfing, Germany). The procedure was replicated three times on separate days, and average values were reported. Samples after baking were cooled to room temperature for about 1 h before sensory and instrumental texture measurements.

2.3. Texture Profile Analysis (TPA)

TPA was performed using a Texture Analyzer Model TA-XTplus (Stable Micro Systems, Ltd., England). An aluminum cylindrical probe was used in a compression test to compress each sample to 35% of its original height with a cross head speed of 20 mm s-1, compression force of 10 N. The Texture Exponent Lite 32 (Vs. 4.9.8.0) software program was used to quantify parameters: hardness (g), adhesiveness (g x s), springiness, cohesiveness, gumminess and chewiness.

2.4.Sensory Analysis

On the sensory analysis, 87 panelists aged from 17 to 25 were recruited in Universitat Politècnica de València. Panelists tasted and described attributes: appearance, color, flavor, sponginess, texture, taste, after-taste, global acceptance. For samples were examined (1 control and 3 alternative flours) in one hour session. Each attribute was rated on a nine-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). Madeleine samples were coded with 3-digit random numbers and presented monadically. Samples were presented following a balanced complete block design. Water was provided for rinsing during the session.

2.5.Statistical Analysis

All determinations were made in triplicate. Data were analyzed using one-way analysis of variance. The mean comparison was carried out using Statgraphic Centurion XVI (Statpoint Technologies, Inc., Warrenton, Virginia, USA).

3. RESULTS AND DISCUSION

3.1.Texture

Changes in texture obtained from TPA of madeleine with wheat and alternative flour are shown in Fig.1. Means with same letters in same attribute are not significantly different ($p>0.05$). Each texture parameters were described separately and then a comparison was made between madeleine prepared with wheat flour and those made with alternative flours.

Springiness, noted as elasticity, reflects how much the structure of tested gel is broken down by the initial compression. High springiness gel results in few large pieces during the first TPA compression whereas low springiness gel results in more small pieces (Lau et al., 2000). Cohesiveness measures the difficulty of breaking down the internal structure of gel. Gumminess, as the product of hardness and cohesiveness, usually is a complementary parameter of hardness (Zhu et al., 2008).

The parameters hardness and gumminess did not result in statistically significant differences ($p>0.05$) between different flours analyzed. Although, in both parameters, the values were lower in sorghum formulations.

Quinoa flour showed significant differences ($p\leq0.05$) in chewiness compared to wheat.

Instrumental adhesiveness show statistically significant difference ($p\leq0.05$) between toasted corn and other flours.

Cohesiveness results showed significant differences ($p\leq0.05$) for the different flours. Toasted corn and sorghum madeleine were less cohesive than others; it would explain the values obtained in the sensory results where these samples were less valued in mouth texture.

Non-significant differences were found in all textural attributes between sorghum and control wheat madeleines.

3.2.Sensory Analysis

In the sensory tests, fifty-four percent of the participants were female and the subjects were between 17 and 25 years old. Table 1 presents the basic statistics referring to the data collected using the 9-point scale.

In all attributes evaluated, wheat flour madeleine was the highest scored. Those results were expected as wheat flour is widely used in the bakery industry and the consumers are related with its sensory characteristics.

Organoleptic evaluation of madeleine, as shown in fig. 2, revealed that, to the global acceptance, wheat madeleine achieved higher scores (7.01±1.44), followed by sorghum (5.85±1.41), quinoa (5.79±1.66) and toasted corn (4.78±1.71).

Sorghum was second on preference. This result must be correlated with obtained in textural properties since the difference in the TPA between sorghum and wheat flour did not reach statistical significance ($p>0.05$).

Color in sorghum flour madeleine was more dark brown than wheat flour. These differences were statistically significant ($p \leq 0.05$) by consumers. Dark colors from black or tannin-containing sorghum varieties might be advantageous in products for the health market (Rooney and Awika, 2005) or in countries where dark, rye-based bread is common (e.g. Germany or Eastern Europe). In such communities, usually ‘‘dark’’ is associated with ‘‘healthy’’ (Taylor et al., 2006). Brannan et al. (2001) found that consumers did accept the color and appearance of a lighter-colored sorghum muffin, resembling a plain or maize muffin as well as a dark brown one, resembling a chocolate, pumpernickel or dark bran muffin.

Whereas appearance, color and sponginess of quinoa and wheat formulations did not differ significantly ($p>0.05$), taste and after-taste were lower scored for quinoa. This flour has a characteristic flavor not easily recognized by the consumers. Mastromatteo et al. (2011) found that the quinoa constituents bring about a bitter taste that affects negatively the overall acceptability of non-conventional gluten-free fresh and dry pasta.

Panelist perceived significant differences ($p>0.05$) among sponginess provided by the different flours.

Consumers expressed their willingness to purchase, intention to consume and recommend each muffin formulation using a dichotomy scale (Fig 3). Consumer were more willing to consume and purchase wheat madeleine (71.3%), followed by sorghum (35.6%), quinoa (31.0%) and toasted corn (14.9%). The highest percentage of positive responses in alternative madeleines belongs to sorghum flour, additionally to the highest overall sensory score by consumers and a similar texture than the wheat madeleines.

4. CONCLUSIONS

The obtained results seem to be a good compromise for the choice of products that bring benefits to sensible populations (as celiac). As substitutes of wheat flour in madeleines production, both sorghum and quinoa flours could be a suitable alternative to conventional madeleines based on their organoleptic and textural properties. These results suggest an opportunity for bakery industry to the introduction of new innovative health products through the use of sorghum flour and other alternative flours.

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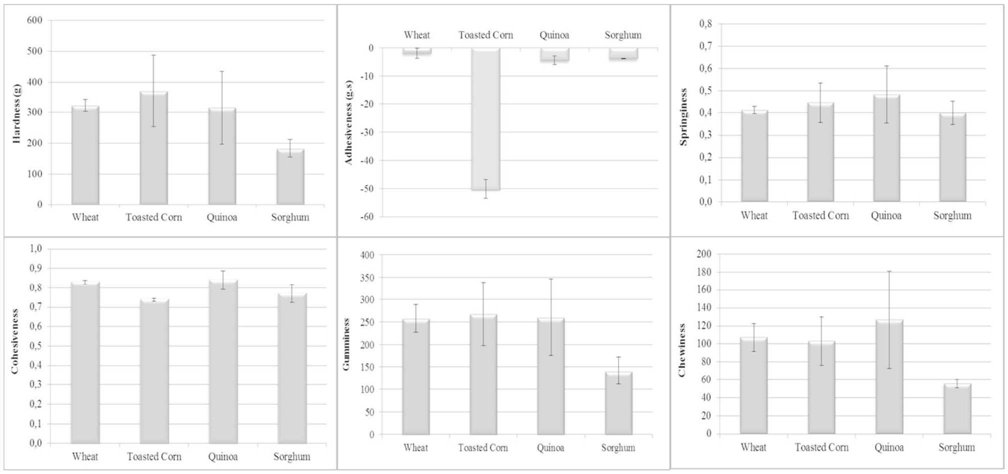
Table 1.- Sensory scores of madeleine formulated with different flours.

Attributes	Formulations			
	Wheat	Sorghum	Toasted corn	Quinoa
Appearance	7.48±1.24^{a}	6.25±1.59^{b}	5.59±1.66^{c}	7.41±1.28^{a}
Color	7.40±1.26^{a}	6.60±1.43^{b}	5.72±1.82^{c}	7.22±1.39^{ab}
Flavor	6.43±1.61^{a}	5.60±1.91^{b}	4.32±2.03^{c}	5.69±1.94^{ab}
Sponginess	6.51±1.68^{abc}	6.21±2.02^{b}	6.31±1.71^{abc}	7.01±1.75^{c}
Texture	6.91±1.63^{a}	5.51±1.89^{b}	4.47±1.96^{c}	5.93±1.96^{b}
Taste	6.83±1.80^{a}	5.40±1.90^{b}	4.20±2.12^{c}	4.94±2.19^{bc}
After-taste	6.68±1.75^{a}	5.56±1.90^{b}	4.46±2.20^{cd}	4.84±2.15^{bd}
Global acceptance	7.01±1.44^{a}	5.85±1.41^{b}	4.78±1.71^{c}	5.79±1.66^{b}

Means with the same letters in the same attributes indicate samples that do not differ significantly ($p>0,05$). These results were obtained using the One-Way ANOVA.



Textural properties
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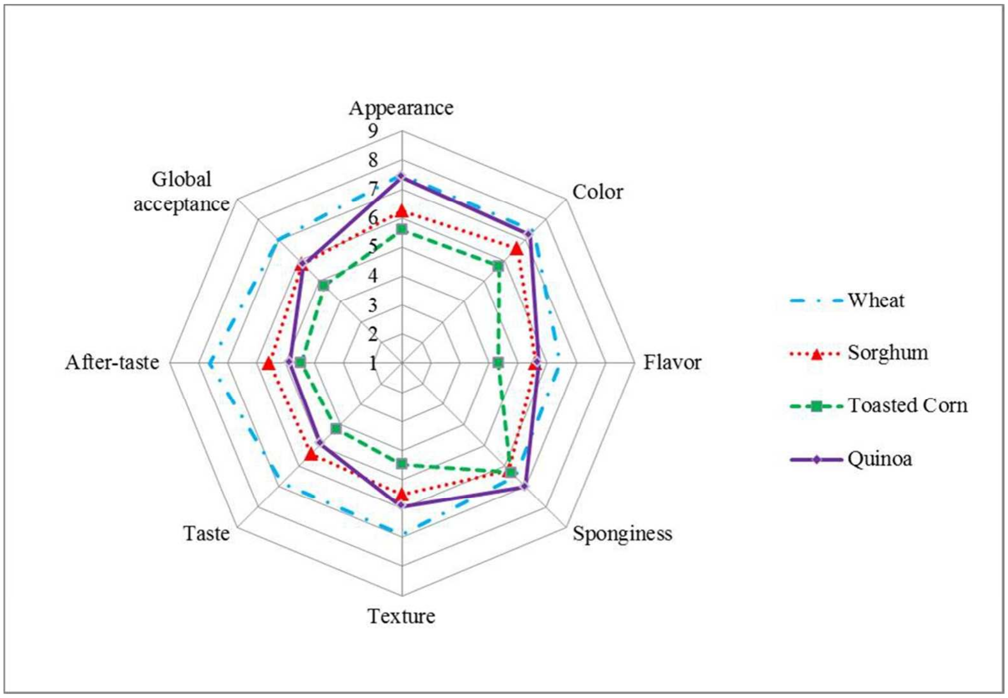

Radar chart of attributes evaluated
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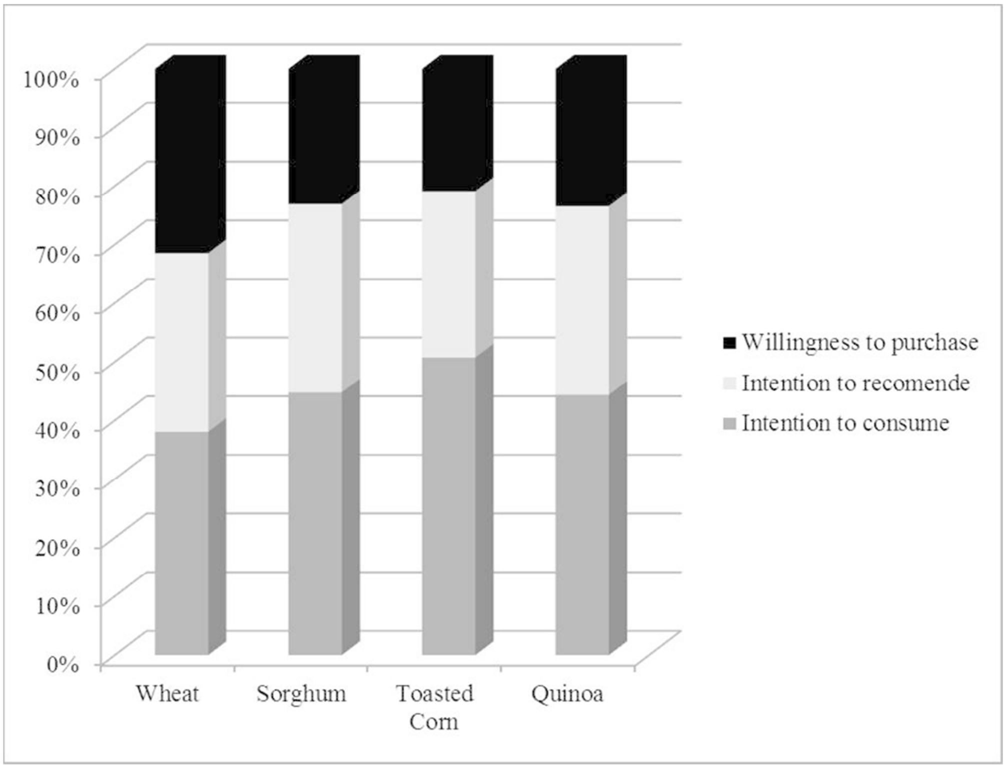

Consumer responses to questions about moment of consumption
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